

those projecting from the outer and lower side of the first and largest pair of secondaries. When there is a narrow margin bordering these veins, the tertiaries proceeding from them are not very strongly developed; but when this margin is wide, they are very strong. Further, when one side is wider than the other the tertiaries of the wider margin are the more strongly developed.

Joining the tertiaries are the quaternaries which also exhibit a tendency to form quadrangular areolae. These, particularly when the tertiaries are strong, may be quite marked, but as a rule they are rather weak.

The nervation may now be briefly described as pinnate and camptodrome, with the two lowest secondaries very much larger than any of the others, while the tertiaries and quaternaries tend to form quadrangular areolae.

Finally, it may be noted that the facts here presented in regard to the form and venation of the leaves studied tend to show that the practice in vogue among paleobotanists of placing more emphasis upon the venation, for purposes of identification, than upon the form, is a sound one, based upon an appreciation of the more constant characteristics of the former.

THE VITALITY OF PINE SEED IN SEROTINOUS CONES

BY J. C. BLUMER

It has long been observed by naturalists that the cones of the group of pines known as jack pines, and some others, often carried closed cones upon their branches for many years. As has been observed for *Pinus attenuata* by John Muir and others, this serotinous character may be a potent factor in producing the aggressive restocking of forest land that has been burned over, characteristic of several such species, a fact of importance in forestry as well as ecology.

In the southwest, this group of pines is represented by *P. chihuahuana*, and it has the same habit of carrying aged cones. One instance is on record in which a cone belonged to a node

originating 16 years previous to the time it was observed, and this period may often be exceeded. Probably it has the same capacity to invade burnt areas, though this the writer has not yet observed.

In order to obtain advantage over other species in such an invasion by this means, the closed cones should preserve vital seed. In the *American Naturalist* for November, 1909, Professor W. C. Coker reviews the literature on the subject, and adds results of his experiments made in 1909 at the New York Botanical Garden. An experiment is quoted as having been made by Professor Sargent in 1879, on the germination of seed extracted from cones of *P. contorta Murrayana* from Colorado, sent him by Dr. Engelmann. Out of 74 seeds held in cones from 7 to 10 years, 15, or 20 per cent., germinated. Seeds from cones 11 and 14 years old did not germinate. The seeds may have deteriorated during the five years in which the branches bearing them lay in St. Louis. Out of 534 seeds obtained by Professor Coker in North Carolina from cones which had been persistent for periods ranging from 4 to 10 years upon *P. serotina*, 226, or 42 per cent., germinated in filter paper and moss, and 307, or 57 per cent., in soil pots. Out of 162 seeds from cones hanging on the trees for 14 years, 40 germinated by the former, and 35 by the latter method, giving percentages of 25 and 22 respectively.

If any further proof is needed that such seeds preserve their vitality for a remarkably long time, the following should furnish it. In experiments made by the writer in the Seed Laboratory of the United States Department of Agriculture in 1904,* the germinative power of seeds of lodgepole pine (*P. contorta Murrayana*) which had been preserved in cones hanging on the trees for a period of 10 to 30 years was compared with that of seeds from cones less than 10 years old. The two lots of seed were gathered by C. A. Scott at Fairplay, Colorado, in 1903, being obtained at the same place and time, and stored in the same place. It will be noted that the species and state were the same as Dr. Engelmann's. The older seeds were separated by counting back 10 internodes from the ends of the branches, and picking the

* Germination of Pine Seed, Miscellaneous, Forest Service, U. S. Dept. Agr., 1907.

cones thence backward as far as found. Out of a total number of 3,000 seeds less than 10 years old, germinated in the laboratory under varying conditions, 928, or 31 per cent., proved vital. Out of 3,000 seeds from 10 to 30 years old, 1,346, or 40 per cent., were found to have preserved their vitality. Under the most favorable laboratory conditions the younger seed germinated 57 per cent., and the older 67 per cent. Six hundred additional seeds of the same lots were tested in soil, and they gave similar results. At Halsey, Nebraska, in nursery tests made by W. H. Mast, the younger seed produced 28 per cent., the older 47 per cent. of seedlings. At Pasadena, California, also in the nursery, T. P. Lukens obtained figures almost identical; viz., 27 per cent. for the younger, 45 per cent. for the older. At Washington, the older seeds only were tested in sand flats kept outdoors in occasional freezing temperatures. The following spring the result was a crop of seedlings amounting to 64 per cent. of the number of seeds planted.

The uniformly higher figures for the older seed does not mean that the seed improved with age instead of deteriorating, but simply that it was seed of better quality and that it probably lost little, if any, of its vitality. It was noted at the time of testing that the younger seed was less well filled, and lighter in both weight and color. In cutting open 400 seeds, it was found that only 53 per cent. of this was filled, as against 73 per cent. of the old seed. The cause did not lie in the direction suggested by a case reported by G. E. Tower,* in which the same species in the same state exhibits marked differences in the time of opening its cones according to the soil on which it grows. For all the seed came from the same stand of trees on the same kind of soil. It is possible that the younger seed came from younger trees, although, as nearly as could be learned, both lots came from the same trees. If the latter is true, the most likely cause would be the unfavorable character of the seasons producing the inferior seed, which might include both weather conditions and parasitic attack. However this may be, there is no longer any doubt as to the longevity of seeds held in serotinous cones.

* Proc. Soc. Am. Foresters, IV, No. 1.

Little difference appeared in the rapidity of germination (germinative energy) of the two lots in question, the seed requiring about 8-10 weeks under the better conditions. High temperatures hastened germination, and low ones retarded it, while the final percentages were lowered by both. Alternating temperatures, with a range of 15°-35° C. (59°-95° F.) or less, simulating the daily fluctuation in nature, proved most efficient in the class of pines possessing the habit of persistence of cones. Of stationary temperatures 35° C. was found to be the best. Although of the six species tested that belong to this class of pines the northern jack pine (*P. divaricata*) is the only one that germinates equally well at low temperatures, few show a decided lowering of their record by high temperatures. The shore pine (*P. contorta*), probably from California, actually made its best record at a temperature of 20°-50° C. (68°-122° F.). If nothing more, this at least indicates that the seeds are able to withstand with little injury a rather high degree of dry heat incident to the fires that open the cones.

Adding an observation on other pine seeds it may be noted that no such deterioration appeared in *P. ponderosa* and its variety *scopulorum* in 18 months as Professor Coker finds for *P. palustris*. Two tests of the first-named pine six months old germinated 68 and 85 per cent. respectively, while four tests 18 months old produced 64, 70, 71, and 85 per cent. of sprouts. The cause for the difference may be partly a matter of storage conditions, and partly an inherent tendency of the species bred by its native climate. In other words, the perishable character of the seed of *P. palustris* may be due, wholly or in part, to the warm and humid climate where the species is indigenous.

REVIEWS.

Macdonald's Dry Farming*

This neatly-bound book with nearly forty photographs illustrating various phases and processes of farming begins with a history of dry farming, which the author claims "has been

* Macdonald, William. *Dry-Farming: Its Principles and Practice*. Pp. 290. Pl. 37. The Century Co., New York. 1909.